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Effect of phosphorus on yield, quality and uptake of nutrients in lentil (*Lens culinaris*) cultivars

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ABSTRACT

A field experiment was conducted during winter(rabi) season of 2012-14 at Raja Balwant Singh College, Bichpuri, Agra (U.P.) to study the effect of phosphorus levels on yield, quality and uptake of nutrients in lentil (Lens culinaris) cultivars. Treatments consisted of four levels of phosphorus (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and three cultivars (DPL-62, Pant-406 and T-36) were evaluated thrice in a randomized block design. The results revealed that the growth characters (plant height, drymatter/plant), yield attributes (pods/plant, grain/pod, grain weight/plant and test weight), were the highest with T 36 cultivar. Grain (15.16q ha^{-1}) and straw (30.07q ha^{-1}) yield were also significantly higher with T 36 cultivar. Application of phosphorus up to 90 kg P_2O_5 ha^{-1} significantly increased the grain and straw yield of lentil genotypes. The magnitude of response to phosphorus application differed from genotype to genotype and were recorded as T 36> Plant 4.7> DPL 62. Growth and yield attributes were improved significantly with phosphorus levels and maximum values were recorded with 90 kg P_2O_5 ha^{-1}. The grain and straw yields increased up to 90 kg P_2O_5 ha^{-1} but did not prove significantly superior to 60 kg P_2O_5 ha^{-1}. Phosphorus application progressively increased the uptake of nitrogen and phosphorus by lentil grain and straw over control. The maximum N and P removal was recorded with T 36 genotype and minimum in DPL 62. Phosphorus application also improved the content and yield of protein in lentil crop. The genotype T 36 registered maximum protein content in grain (3.94%) and straw (22.0%) and protein yield (333.5 kg ha^{-1}).

Key words: Phosphorus, quality, yield, lentil, cultivars.

INTRODUCTION

Lentil (*Lens culinaris Medik*) is one of the important pulse crops in India. India contributes almost half of the world lentil production. However, its national average productivity (706 kg /ha) is still very low. The low yield of crop is mainly due to cultivation of traditional low yield of varieties without or with lentil fertilization and lack of other improved agronomic practices. In recent years, many new promising genotypes of lentil have been developed. These genotypes not only have good adoptability but also are high yielding and disease resistant. Proper nutrition of the crop in respect of phosphorus can improve its productivity. Phosphorus is the key nutrient that limits the lentil production. Pulses are known to be responsive to phosphorus fertilization and lentil is relatively more responsive to phosphatis fertilizers by virtue of its profuse branching, deep and extensive root system. Phosphorus (P) plays many key roles in crop growth. It is referred to as “King pm” of agriculture. Phosphorus containing adenosine triphosphate (ATP) is the “energy currency” of the plants. The p use efficiency varies from 15 to 25 percent.However, there is a need to quantity the requirement of phosphorus for the lentil crop with particular condition to the cultivars. The reliable information the vital agro-techniques for successful cultivation of lentil in Agra region is absolutely lacking. The present studies were undertaken to identity suitable cultivar and estimate the optimum phosphorus dose for maximum productivity of lentil in Agra region of Uttar Pradesh.

MATERIALS AND METHODS

A field experiment was conducted during rabi seasons of 2012-13 and 2013-14 at R. B. S. College farm, Bichpuri (Agra) The experimental site falls under South-west semi-arid zone and characterized by semi-arid climate with extreme temperature during summer (45 to 48° C) and very low temperature during winter (as low as 2°C). The average rainfall is about 650 mm, most of which is received from June to

September. The experimental soil was sandy loam in texture typic Ustochrept having pH 7.9, organic carbon 3.1 g kg^{-1}, available N 156 kg ha^{-1}, available P 9.0 kg ha^{-1}, available K 106 kg ha^{-1} and available S 15 kg ha^{-1}. The experiment was laid out in randomized block design with three replications. The treatments consisted of four rates of P (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and three genotypes (DPL-62, Pant-406 and T 36). Lentil was sown in first week of November in both the years. A basal dose of 20 kg N and 40 kg K_2O ha^{-1} was applied through urea and muriate of potash, respectively. Appropriate management practices were adopted to raise the crop. Crop was harvested at maturity. Growth and yield attributes in the crop were recorded at harvest. Seed and straw samples were digested in di-acid mixture of HNO_3: $HClO_4$ (10:4) and sulphur content was determined turbiditimetrically (Chesnin and Yien, 1951). Phosphorus and K in di-acid digest were determined by vanadomolybdate yellow colour method (Jackson, 1973) and flame photometer, respectively. Nitrogen content was estimated by modified Kjeldahl method and protein content was calculated by multiplying with a factor of 6.25. The uptake of nutrients was obtained as product of their concentrations and yield.

RESULTS AND DISCUSSION

Phosphorus application increased plant hight and dry matter/plant. The tallest plants were recorded with 90 kg P_2O_5 ha^{-1}. Dry matter accumulation increased significantly with every increase in the level of phosphorus application up to 60 kg P_2O_5 ha^{-1}. However maximum values of plant height and dry matter/plant were recorded with 90 kg P_2O_2 ha^{-1}. The increase in these growth attributes may be owing to the improvement in vigour of the plants possibly by balanced supply and higher uptake of nitrogen and phosphorus (Chauhan and Raghav, 2017). Lentil variety T 36 had significantly higher plant height and dry matter/plant than the other varieties (Table 1). The lowest values of plant height and dry matter/plant were associated with DPL-62. Production of the highest growth attributes with T 36 might be due to its potential for profuse rooting and branching ability in the domain of investigation over which might be due to reverse response, since the varieties susceptible to P deficiency, would lead to poor growth. It also reduced canopy photosynthesis and thereby the lower growth parameters Chaudhary *et al.* (2006) reported similar results in cluster bean.

Table 1: Effect of phosphorus levels on growth, yield attributes and yield of lentil cultivars at harvest (mean of two years)

Treatment	Plant height (cm)	Dry mater/ plant (g)	Pods/plant	Grain/pod	Grain weight/plant (g)	Test weight (g)	Yield (q ha^{-1})	
							Grain	Straw
Phosphorus (kg ha^{-1})								
0	36.2	3.43	77.4	1.70	3.10	26.74	10.99	19.44
30	39.7	4.00	102.8	1.87	3.81	27.54	14.34	29.10
60	42.3	4.53	119.4	1.91	4.06	27.65	15.45	32.71
90	42.8	4.76	119.9	1.91	4.09	27.79	15.61	33.51
SEm ±	0.42	0.15	3.26	0.023	0.034	0.22	0.15	0.57
CD (P=0.05)	1.23	0.45	9.79	0.068	0.103	0.66	0.45	1.70
Cultivars								
DPL-62	39.1	3.92	98.7	1.77	3.51	26.34	12.79	26.11
Pant-406	40.1	4.19	103.6	1.85	3.79	27.63	14.34	29.83
T-36	41.5	4.43	111.6	1.91	4.00	28.32	15.16	30.07
SEm ±	0.36	0.13	2.83	0.021	0.031	0.19	0.13	0.54
CD (P=0.05)	1.07	0.39	8.29	0.060	0.091	0.57	0.39	1.61

Cultivar produced significantly higher number of pods/plant, grains/pod, grain weight/plant and test weight than all the other varieties (Table 1). The lowest values of these yield attributes were recorded with DPL-62. Differential behaviors among the varieties could be explained solely by the variation in their genetic makeup and their differential behavior under different climatic conditions. This has been documented by Chaudhary (*et al.* 2006) in cluster bean and Saket *et al.* (2017) in field pea. Increasing levels of P up to 90 kg P_2O_5 ha^{-1}

significantly enhanced the number of pods/plant, grains/pod, grain weight/plant and test weight over other levels of phosphorus. However, both the levels of P (60 and 90 kg P_2O_5 ha^{-1}) were significantly after with respect to yield attributes. This behavior of P levels may be attributed to differential availability of P under different P levels (Singh *et al.* 2014). The lowest values of these parameters were recorded with control. Application of 90 kg P_2O_5 ha^{-1} resulted in higher grain and straw yield than control, 30 kg and 60 kg P_2O_5 ha^{-1} but at par with 60 kg P_2O_5 ha^{-1}. Increased grain and straw yield owing to phosphorus application could be ascribed to improved biomass production contributing towards yield attributes. Positive effect of phosphorus on grain and straw yields was also reported by Singh *et al.* (2014) and Chauhan and Raghav (2017). There were also significant variations in grain and straw yields of lentil among its genotypes. Genotype T-36 produced significantly higher yields of grain and straw than other two genotypes (Pant-406 and DPL-62). The higher yield could be attributed to higher dry matter production and cumulative effect of yield attributes indicating the suitability of variety for growing in a prevailing climatic condition. These results are in close conformity with those reported by Chaudhary *et al.* (2006) and Saket *et al.* (2017).

Quality

The highest protein content in grain (22.12%) and straw (4.00%) was obtained with 90 kg P_2O_5 ha^{-1} which was significantly higher than the control. Significant increase in protein content may be attributed to increased N content with P application. Nitrogen being the precursor of protein increased the grain and straw protein content accordingly (Chauhan and Raghav 2017). Genotype T 36 recorded significantly higher protein content in grain (22.00%) and straw (3.94%) than the other genotypes. Among these genotypes the minimum value of protein content was recorded in grain and straw of plant 406 genotype. The results may be attributed to genetic variability of different genotypes and effect of agro-ecological condition on different genotypes. The protein yield increased significantly up to the level of 90 kg P_2O_5 ha^{-1} over control. This was statistically at par with 60 kg P_2O_5 ha^{-1}. Since protein yield is mainly the function of grain yield and protein content in grain, the protein yield increased with P levels (Singh and Singh 2017). The maximum value of protein yield was recorded in T 36 genotype of lentil (333.5 kg ha^{-1}) followed by 406 (311.6 kg ha^{-1}) and DPL-62 (277.9kg ha^{-1}). The increase in protein yield may be attributed to higher production of grain yield and an improvement in protein content.

Table 2: Effect of phosphorus on quality and uptake of nutrients in lentil cultivars (mean of 2 years)

Treatment	Protein content (%)		Protein yield (kg ha^{-1})	Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})	
Phosphorus (kg ha^{-1})							
0	21.68	3.69	238.2	38.1	11.5	2.3	1.9
30	21.73	3.07	311.6	50.3	18.0	3.4	3.5
60	22.00	3.94	340.0	54.4	20.6	4.0	4.2
90	22.12	4.00	345.3	55.2	21.4	4.4	5.0
SEm ±	0.06	0.04	4.05	0.73	0.20	0.06	0.04
CD (P=0.05)	0.17	0.11	12.02	2.18	0.59	0.17	0.11
Cultivars							
DPL-62	21.73	3.87	277.9	44.9	16.2	3.3	3.4
Pant-406	21.73	3.81	311.6	50.3	18.2	3.6	3.3
T-36	22.00	3.94	333.5	53.4	18.9	3.6	3.6
SEm ±	0.06	0.04	4.05	0.73	0.20	0.06	0.04
CD (P=0.05)	0.17	0.11	12.02	2.18	0.59	0.17	0.11

Nutrient uptake

Phosphorus application had a significant beneficial effect on nitrogen uptake by lentil grain and straw over control. With the successive increase in P levels from 0 to 90 kg P_2O_5 ha^{-1}, the uptake of nitrogen in grain and straw increased from 38.1 to 55.2 and 11.5 to 21.4 kg ha^{-1}, respectively. This might be owing to increased P availability and yield of lentil grain and straw. Similar results were reported by Chaudhary *et al.* (2006) and Singh *et al.* (2017).

Genotype T 36 recorded significantly higher nitrogen uptake by grain (53.4 kg ha^{-1}) and straw (18.9 kg ha^{-1}) than rest of the genotypes, whereas minimum nitrogen uptake was recorded in DPL-62 genotype. These results may be attributed to special capability of the genotype for absorbing more nitrogen from soil. Similar finding were also reported by Saket *et al.* (2017). Application of phosphorus significantly increased its uptake by lentil genotypes over control. The maximum uptake of P by lentil genotypes was recorded with 90 kg P_2O_5 ha^{-1}. This increase in P uptake may be attributed to increase in P content in lentil crop and grain and straw yield, due to rising phosphorus levels. Singh *et al.* (2016) and Singh and Singh (2017) also reported similar results.

The different genotypes had varying phosphorus uptake and genotype T 36 recorded highest phosphorus uptake in grain and straw followed by Pant-406 and DLP-62. It can be attributed to ability of the genotype to absorb high amount of phosphorus from soil (Saket *et al.* 2017). Based on 2 years of field study, it may be concluded that the application of phosphorus @ 60 kg P_2O_5 ha^{-1} to the lentil genotypes, is sufficient dose for the increased productivity and quality of lentil crop. The genotype T 36 was found superior in respect of yield and quality. The farmers are advised to grow the genotype T 36 with 60 kg P_2O_5 ha^{-1}.

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